CubeRover for Mobility as a Service

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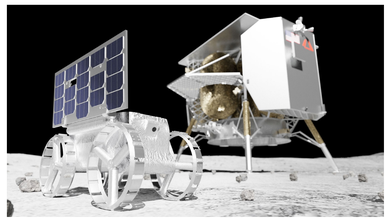
Introduction

The CubeRover is a first of its kind ultra-light, modular, and scalable commercial rover. Combined with commercial payload services available, it offers a low-cost onramp to the Moon for payload developers globally. CubeRovers utilize a methodology akin to CubeSats in that they support diverse instrument packages in a standard form factor. CubeRovers leverage the internationally recognized CubeSat sizing method to define the payload volume and carrying capacity, where a 10 cm X 10 cm X 10 cm volume that supports 1 kg of payload is called a unit or "U." Accordingly, the 2U CubeRover has a payload volume of 20 cm X 10 cm X 10 cm and supports 2 kg of payload. The 4U and 6U CubeRovers are also available, and their carrying capacity correlates with their respective U designation. Larger versions of the rover utilize the same structural, power, thermal, avionics, and software systems to minimize re-engineering costs. CubeRovers are highly customizable to meet the needs of precise payload demands.

Lunar Applications



CubeRovers can be used to inspect and interact with landers and critical equipment on the lunar surface. They can also be used in tandem and coordination with other larger rovers.

- Resource prospecting
- In-situ resource utilization
- Sampling
- Geodetic characterization
- Magnetic mapping
- Lava tube mapping
- Marsupial missions
- Distributed swarms
- Infrastructure monitoring and maintenance

➤ *CubeRover is designed to address Lunar SKGs*

Lunar Payloads

- Magnetometers
- Ground penetrating radar
- Neutron detectors
- Spectrometers
- Gravimeters
- Retrofreflectors
- Penetrometers
- Electrometers
- Dosimeter
- Imaging systems
- Robotic arms

Astrobotic is currently working with teams to integrate a neutron detector and ground penetrating radar on its 4U and 6U CubeRovers. The CubeRovers pictures above are prototypes recently delivered to the NASA Kennedy Space Center.

About Astrobotic's Planetary Mobility

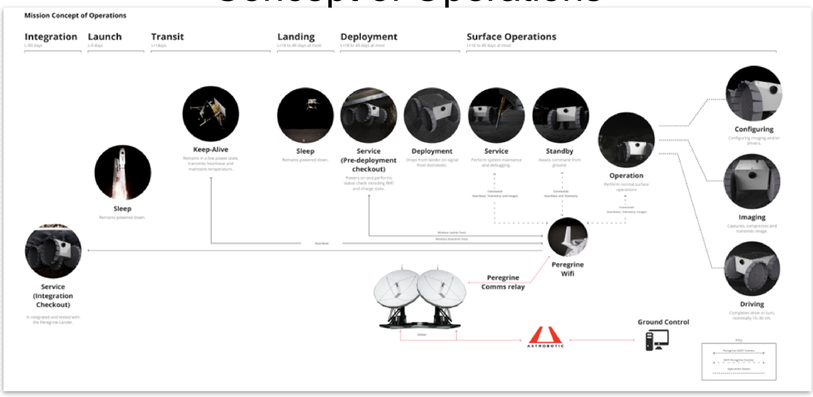
Astrobotic's Planetary Mobility team is bringing down the barriers to entry for mobility services on planetary bodies. From rovers, to wireless chargers, to ground software, we deliver cutting edge technology that pushes the envelope of what's possible for science payloads and technology demonstrations. Email us at *pm@astrobotic.com*.

Payload Services

An overview of payload services that each CubeRover provides is shown in the table below and is detailed in the CubeRover Payload User's Guide on Astrobotic's website.

	2U	4U	6U
Rover Mass	3 – 4 kg	6 – 8 kg	10 – 12 kg
Payload Capacity	Up to 2 kg	Up to 4 kg	Up to 6 kg
Internal Payload Max Dimensions	20 x 10 x 10 cm	20 X 20 X 10 cm	30 X 20 X 10 cm
Payload Nominal Power Services	0.5 W per kilogram continuous, 10 W peak		
Payload Power Interface	28 Vdc		
Payload Thermal Environment	+10C to +30C		
Payload Wired Interface	RS-422		
Payload Comms Services	10 kbps per kilogram		
Payload Wireless Standard	WLAN 802.11n		
Payload Data Storage	32 Gb +		

Concept of Operations

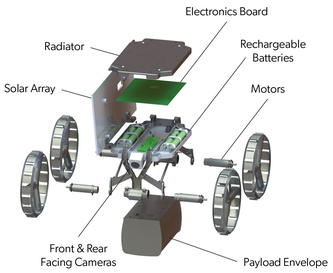


OFF MODE	**Off State** Battery electrically disconnected from the rover.
TRANSIT MODE	**Transit State** Reduced functionality. Rover supports mimimum services to maintain survival temperature. Battery electrically disconnected from the rover. Heater is enabled and uses power from Lander. Payload processor can be on.
ON MODE	**Power-On Self-Test State (POST)** Execute routines to verify integrity of the rover at boot-up, enter Service State upon failure.
	Pre-deployment State Rover enables main processor, battery system and wireless interface. Functional check on every sub-system. State exits before deployment command is executed successfully.
	Deployment State Rover engages deployment system, touches the lunar surface and engages a rove-to-sun command to open and orient solar panel normal to the sun.
	Stand-by State In the absence of workload, CubeRover enters Stand-By state where only radio and are heaters enabled, Main processor is in an idle state and solar panel oriented normal to the sun.
	Operational State State used during the mission to perform navigation, imaging, localization and payload processing.
	Safe State Enter automatically when an error occurs. Minimum service enabled until operator assesses situation and resolve problem.

Contact us today at pm@astrobotic.com to get your payload manifested on a CubeRover to the Moon.

System Overview

The CubeRover uses four aluminum wheels. Each wheel is independently actuated, with its own motor and gearhead. These flight-qualified actuators are powered by several flight-qualified battery cells and a deployable solar array controlled by a custom onboard single board computer (SBC). The SBC serves as the flight computer for the CubeRover, covering command and data handling, image processing, motor control, and power management and distribution. 5-Megapixel monocular image sensors are mounted to the front and rear of the CubeRover to provide navigation and localization capabilities. The CubeRover communicates to the lander through an 802.11n WiFi connection. To enable this, a WiFi radio module is included on the SBC. All thermally regulated components are thermally grounded to the rover's top-mounted radiator. The outside of the rover chassis is lined with multi-layer insulation (MLI) to reduce thermal transfer from the avionics (during transit) and from the regolith (during operations). Payloads are typically mounted inside the MLI enclosure to control the thermal environment and mitigate dust ingress. Two hold-down and release mechanisms and a set of pogo pins are mounted to the top of the radiator as part of the stowage and deployment interface from the lander deck



An exploded view of the CubeRover.

Price

Astrobotic offers mobility as a service for $4.5M per kilogram of mobile payload delivered on the lunar surface, which includes end-to-end delivery to the Moon on Astrobotic's Peregrine or Griffin landers. This firm fixed price service includes creation of all designs and analyses of the integrated payload and CubeRover; fabrication of the CubeRover flight model; fabrication of a CubeRover engineering model for the payload developer to utilize in preparation for the mission; integration of the payload on the CubeRover; integration of the CubeRover on Astrobotic's Peregrine or Griffin lander; selection of launch opportunities; determination of overall mission architecture; provision of end-to-end standard payload services including operations associated with the launch vehicle; launch site selection; spacecraft; lander; mission design and analysis; ground systems; payload support throughout the mission. It is also possible to purchase a CubeRover and fly it on another lunar lander. Contact us to today to explore this further.

Current Status

- The CubeRover has been assessed at TRL 4/5
- Batteries are flight qualified and will be used on the SLS
- Motors are flight qualified and will be used on the Perseverance rover.
- The software framework has flight heritage.
- Testing to verify analytical results of low fidelity prototypes was achieved at NASA Glenn Research Center in May 2018
- Verification testing for a high-fidelity engineering unit is currently in progress using BP-1 lunar simulant in the Kennedy Space Center's GMRO Lab.
- Vibration, thermal vacuum, and EMI tests will be performed Spring 2021.

Acknowledgement

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